Reproductive strategies and seeds behavior of *Betula platyphylla* Suk. population

YUAN Xiao-ying (袁晓颖)*, MAO Zi-jun (毛子军), GU Hui-yan (谷会岩), ZHAO Yu-xiang (赵玉香)
ZU Yuan-gang (祖元刚), ZOU Li (邹莉)
(*Northeast Forestry University, Harbin 150040, P.R. China*)

Abstract: By the methods of morphological anatomy and investigation in the sample fields, the main studies were carried out such as morphological anatomy of reproductive organs, birch population's reproductive ages, reproductive allotment value and seed behavior. The relationship between birch population and their surroundings was studied. The results showed that birch's flower organs and its seeds were suitable well for spreading by wind. The seeds by wind can fly far away in a short time. The quantity of seed spreading greatly varied with different communities. Birch's reproduction age can be changed in different ecological surroundings. The reproductive allotment value of birch was obviously different at different reproductive stages. In the mesic habitat, birch can grow well. The lowest reproductive age of them was 12, average age 15. In most cases the age of branches to bearing fruits was more than 18. The order of reproductive allotment values was as follows: a flowering phase > flower bud phase > fruit phase.

Key words: Birch population; Reproductive strategies; Seed behavior
CLC number: S792.153.04 **Document code**: A **Article ID**: 1007-662X(2000)04-0241-04

Introduction

Birch (*Betula platyphylla* Suk.) is a photophilous and broad-leaf tree species, which is distributed widely in the northeast of China, especially in clear cutting or burned forest areas after the original vegetation is damaged (Zhou 1986). Birch is just a pioneer tree species through secondary-forest succession. Since birch population often grows rapidly in a large area, it usually has a great amount of seed storage. Its timber is an important raw material in building materials, such as plywood, veneer, etc.. Its foresight is broadly prospected on exploration and application. At present the birch population is not only thought to be a dominant and fast growing tree species, but also is known as "erupt type population" (Sun 1994a; 1994b). The authors probe into the reason that the birch population burst out for growth, from the respects of reproductive strategies and seed behavior.

Study sites

The sample fields were located in the Mao'ershan Experimental Forest Farm of Northeast Forestry University, near the southeastern part of Heilongjiang Province. The total area was 26 507 hm^2. The geographical location is 127°28'20"-127°43'14" in longitude and 45°14'30"-45°29'20" in latitude. Seven communities were selected, of which 4 situated in mesic habitat and 3 in wet habitat, with each area of 20 m×20 m (Table 1).

Research methods

The reproductive organs were observed by morphological anatomy, and reproductive ages of birch population in various sample fields were investigated. The reproductive allotment values of 4 kinds of birch communities in four mesic habitats were measured three times during the whole growth season. The ages of birch communities measured were 12, 22, 34, 56, 87, respectively. We worked out four directions of each tree with diagonal lines, and then divided the canopy into three layers i.e. upper, middle and lower. We took three reproductive branches on each diagonal line at each layer. So we got 12 reproductive branches from one tree. The biomass of branches, buds, inflorescences, fruits and leaves was weighed individually. The organs above were separately dried in oven at 80 °C for a few minutes, and then the temperature was kept at 110 °C until they had a permanent weight. The biomass of reproductive allotment value of branch could be counted. The counting formula is as follows:

Biography: * YUAN Xiao-ying (1950-), female, professor in Northeast Forestry University, Harbin 150040, P.R. China.
Received date: 2000-08-04
Responsible editor: Zhu Hong

$$R_A = \frac{R_{SW} + R_{ASW}}{T_{WRB}} \times 100\%$$

Where: R_A is the reproductive allotment value; R_{SW} is the weight of reproductive structures; R_{ASW} is the weight of reproductive attachment structures; T_{WRA} is the total weight of reproductive branch.

Seed rain method was adopted in research on seed behavior (Yang 1990, Yang 1991). On the 28th of July 1997, the seeds were nearly ripe. The seed-receiving plates (0.5 m×0.5 m) were placed in seven sample fields along diagonal lines. There were three seed-receiving plates on each diagonal line. The distance between one plate and another was 3.5 m. There were twelve seed-receiving plates in each sample field. Finally, the seed number was counted in seed-receiving plates. We selected a community i.e. *Carex callitrychos--Corylus heterophylla--Betula platyphylla* forest, then put nine seed-receiving plates in 50 m or 100 m away from the forest edge separately in the east, southeast and south of this community, in order to investigate the spreading distances of seeds.

Table 1. The communities in sample field

No.	Name of community	Habitat	Number of trees	Age of Birch/a	Canopy density
1	*Carex callytrichos--Corylus heterophylla--Betula platyphylla* forest	Mesic habitat	21	15-87	0.6-0.7
2	*Pinus sylvestris* var.*mongolica --Betula platyphylla* forest	Mesic habitat	19	20-35	0.8
3	*Carex* sp.-*Spiraea salicifolia--Betula platyphylla* forest	Mesic habitat	24	7-60	0.6
4	*Larix gmelini --Betula platyphylla* forest	Mesic habitat	18	10-37	0.7
5	*Carex* sp.--*Salix rosmarinifolia* var. *brachyploda--Betula platyphylla* forest	Wet habitat	14	15-35	0.4-0.5
6	*Carex rhynchophysa--Sorbaria sorbifolia--Betula platyphylla* forest	Wet habitat	9	13-35	0.5
7	*Lonicera chrysantha--Betula platyphylla* forest	Wet habitat	21	10-45	0.7

Results and discussion

Adaptive strategies of reproductive organs

By observing the anatomy structure of the birch's flower organ, its pollinate was suitable for spreading by wind. Male inflorescence is at the top of the branch. The floral envelope blade degenerates into a membrane character without nectary. While blooming, the female flower comes from a leaf axil. Glands that can secrete sticky juices are exited on the top of a floral bract, which offered stigma to be sticky during the pollination period and easy to absorb pollen. Any parts of sticky stigma can receive pollen and complete insemination. The surface of pollen is dry, projecting thorn is small and the volume of pollen is small with a lightweight. It is easy to spread by wind (Chen 1991). The characteristics of flower organ structures are very important to complete pollination and to raise the rate of bearing fruits. This must be the foundation to form a large amount of reproductive individuals. Birch seeds have the attachment structures i.e. seeds with seed wings of membranous character were suitable for spreading by wind. The seeds of birch have very strong herb-against characters, which offer a guarantee for expanding population

Strategies of changing reproductive age by ecological environments

The first stage of reproductive age is various for birch population because of the different origins and different ecological environments (Su 1996). According to research, in the mesic habitat, birch can grow well. The lowest reproductive age of them is 12, average age 15. When forest canopy density is large, the individual birch trunk under its branch is higher than that of other trees. The angle of branches is very small. So the canopy density is very small. In most cases the age of branches to bearing fruits is more than 18, some of them were more than 20 years old (Fig. 1).

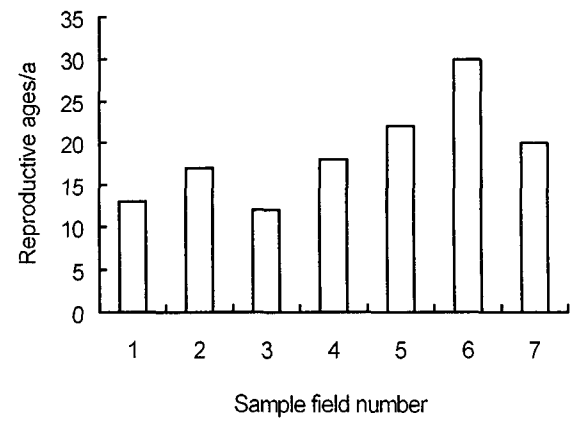

Fig. 1 The beginning reproductive ages of birch in different sample fields

From Fig. 1, it is found that the beginning reproductive age of birch in the wet habitats in sample field No.5, 6 and 7 had clearly difference from those growing in mesic habitats (Fig. 1). Those birch trees

in *Carex* sp.--*Sorbaria heterophylla*--*Betula platyphylla* forest in wet habitation can't bear fruits until the age of 30. This showed that birch could adapt to different ecological environments.

A lot of birches germinated in various communities. At the age of 6 they begin to reproduce, whereas the average age is about 8. The birch individuals that originate from the base of the trunk begin to reproduce mostly at older age. This is because the growth of the main trunk restrains individual parts.

Reproductive allotment strategies

Reproductive age and reproductive allotment value

The reproductive age of individual directly affects the reproductive allotment value of its reproductive branches (Zhong 1995). In May 1998, we measured reproductive allotment value of branches when birch was just about to flower. The results were as follows (Fig.2).

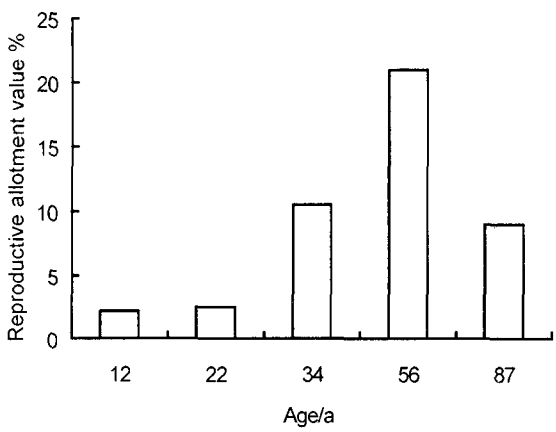

Fig. 2 The reproductive allotment value of birch individuals at different ages during flowering period

Before the age of 56 (Fig. 2), the reproductive allotment value of branch increased with the individual age. The maximum reproductive allotment value appeared at age of 56, and then it began to decrease, as the age increasing. The reproductive allotment value of 87-year-old trees is only around 2/5 of that of 56-year-old trees, but it is still higher than that of 12-year-old trees. By observing in the field, we know that, for old age birch, its branches are thin and weak, nearly having no growth. The old age birch has a large amount of reproductive organs, and its net growth is used basically for reproductive growth besides the growth of bud and leaf. From Fig. 2, the results showed that reproductive allotment value was very low before the age of 30, during that time, the birches struggle for existence intensely. They occupied the upper layer of community after they grew upward rapidly through struggle for resources, and then their branches turned to reproductive growth.

Reproductive stage and reproductive allotment value

We measured the reproductive allotment value of birch at different reproductive stages throughout the whole growth season (Table 2).

Table 2. Reproductive allotment value (RA) of birch at different reproductive stages

Age/a	Flower bud phase	Flowering phase	Fruit phase
12	1.88	4.19	1.46
22	2.30	5.13	1.79
34	9.00	20.07	7.00
56	20.05	44.71	15.60
87	8.20	18.29	6.38

The birch's reproductive allotment patterns are extremely similar at different reproductive stages with various age individuals. The order of reproductive allotment values is as follows: a flowering phase > flower bud phase > fruit phase. During the period of flower bud phase, the nutrients transported from roots and stems basically to reproductive organ. Therefore the flower buds with male inflorescence grow vigorously, and the leaves do not unfold until the flowering phase. When the phase of the flower buds open, the female inflorescence appears and begins to grow, but the male inflorescence hangs down loosely. At this moment, the reproductive allotment value of biomass is the greatest. At the fruit phase, lots of leaves and branches in this year have the maximum biomass. Male inflorescence just formed in the following year, where water decreases after fruit (seeds) matured. As a result, it has the lowest reproductive allotment value of during this period. All of this showed an evolution relationship in coordination (Yang 1991; Chen 1991; Su 1996)

Seed behavior strategies

For some plant populations, they have strong abilities of invasion, which are decided by their various seed behavior. Various seed behavior is referred to the whole plant species character, which can make seed groups from the same tree to germinate separately in a certain time and space. Spreading seed groups may germinate at different places. Birch as a long life woody plant, after getting into the reproductive age, produces a large quantity of seeds. Each female inflorescence may form over 350 grains of seeds. So the total of seeds number of one tree will be very large. Compared to other tall arbor, it has absolute predominance for its quantity of seeds has expanded its population size. From this aspect, the ecological strategies of birch are typically " r " strategies. Through its whole living history, birch has a higher the reproductive frequency and will produce a

large amount of seeds every year. Its seeds by wind can fly far away in a short time. The quantity of seed spreading greatly varied with different communities.

Table 3. The amount of birch seeds spreading in different communities

Type of community	Seed number /grains·m^{-2}
Carex callytrichos--Corylus heterophylla--Betula platyphylla forest	6 345
Pinus sylvestris var.*mongolica--Betula platyphylla* forest	4 725
Carex sp.*--Spiraea salicifolia--Betula platyphylla* forest	5 372
Larix gmelini--Betula platyphylla forest	6 213
Carex sp.*--Salix rosmarinifolia* var. *Brachyploda--Betula platyphylla* forest	3 147
Carex rhynchophysa--Sorbaria sorbifolia—Betula platyphylla forest	2 522
Lonicera chrysantha--Betula platyphylla forest	4 529

From Table 3, the amount of seeds dispersed in *Carex rhynchophysa--Sorbaria sorbifolia--Betula platyphylla* forest is the least. In mixed forests, the number of seeds dispersed in *Larix gmelini--Betula platyphylla* stand is larger than that in *Pinus sylvestris* var. *mongolica--Betula platyphylla* forest. The number of seeds in *Carex callytrichos--Corylus heterophylla--Betula platyphylla* forests is the largest. Observing different communities with different canopy densities and in different wet conditions (Table 1), we have found that the amount of seeds spreading is greatly interrelated to illumination conditions, water conditions and also forest age. In suitable mesic habitats, the number of birch trees is large with a high quantity seed spreading. By observation, we have found that most of seeds fall in the community after they get ripe. And 19.5% of the seeds fall in the forest edge. It is supposed that if the conditions were suitable for seeds to germinating, the amount of seedlings would be quite considerable in this place.

References

Zhou Yiliang, Tong Shilin and Nie Shaoquan. 1986. Ligneous flora of Heilongjiang [M]. Harbin: Heilongjiang Science Press, 185-199.

Chen Zhiduan.1994. Phylogeny and phytogeography of the *Betulaceae* [J]. Acta Phytotaxonomica Sinica, **32**(1): 1-31.

Sun Bing, Yang Guoting, Chi Fuchang *et al.* 1994a. Study on the spatial pattern of *Betula platyphylla* population [J]. Bulletin of Botanical Research, **14**(2): 201-207.

Sun Bing, Yang Guoting, Li Hong *et al.* 1994b. Study on the age structure of *Betula platyphylla* population and the succession of its community [J]. Journal of Northeast Forestry University, **22** (3): 43-47.

Chen Zhiduan. 1991. Pollen morphology of the *betulaceae* [J]. Acta Phytotaxonomica. Sinica, **29**(6): 494-503.

Su Zhixian, Zhong Zhangcheng, Yang Wanqin *et al.*1996. Studies on the reproductive ecology of *Gordonia acuminata* population. I. Studies on the reproductive age, reproductive age structure and their affecting factors [J]. Acta Ecologica Sinica, **16**(5): 517-524.

Zhong Zhangcheng. 1995. Reproductive strategies of plant population [J]. Journal of Chinese Ecology, **14** (1): 37-42.

Yang Yunfei. 1990. The study on seed dispersal of *puccinellia tenuiflora* on alkalization meadow in the Songnen plain of China [J]. Acta Ecologica Sinica, **10**(3): 288-290.

Yang Yunfei and Zhu Tingcheng. 1991. The study on seed rain change of *Stipa grandis* community in the songnen plain of China [J]. Acta Phytoecologica *et* Geobotanica Sinica, **15**(1): 46-54.